4.0 V&V Status and Usage History

This portion of ASP I summarizes applications employing ALARM, and the extent to which those applications have been supported by documented V&V. ALARM has a large number of users with a wide variety of applications.

The Users Group Points of Contact (POCs) Listing in Appendix B includes 173 individual entries from approximately 120 government organizations and commercial firms. A breakdown of these groups by DoD Service is shown in Table 4.0-1 below. A potential user of ALARM seeking information to support accreditation could perhaps take comfort in the fact that this large and diverse user group places some degree of confidence in model results.

Table 4.0-1 ALARM Users by Category

User Category	Number
Air Force	42
Army	8
Navy	5
Other DoD	4
Other Gov't	3
Federally Funded Research & Development Contractor	5
Commercial Firms	56
TOTAL	123

In 1992 a questionnaire was sent to the ALARM user community, seeking information about the use and V&V of ALARM [23, 24]. This survey was carried out, in part, because of the lack of formal V&V documentation. Table 4.0-2 summarizes the results by question received from the 31 users that responded.

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Table 4.0-2 ALARM Users Group Survey Results

Brief Form of Question	YES Responses
Perform any V&V analysis?	9
Accredited for a specific project?	1
Results compared with other models?	13
Results compared with test data?	8
Problems, errors, or weaknesses?	12
Obtained Interface Requirements Specification?	1
Obtained test plans/reports?	3
Developed in-house documentation?	5
In-house configuration management practices?	9

Many respondents provided comments beyond the questions. A follow-up survey with telephone calls to some of the respondents was conducted. This additional information is summarized below.

Table 4.0-3 Specific Results of Survey and Follow-up

Organization/ Firm POC	ALARM Version	Test Data	Other Models Compared	Problems Found	In-house Doc	In-house CM
Northrop ESD/Rolling Meadow Jeff Zeller (708) 259-9600 x24812	86/88	Y	TRAJ-II	Y	Y	Y
ASC/XRE Klaus-Peter Bletzinger (513) 255-2821	86, 88, 90, NAVY	Y	Y	Y		Y
SURVIAC Denny Detamore (513) 429-9509	87?,88		Y	Y	Y	Y
IDA Merle Robertson (703) 845-2273	88					
WL/AAWA Russel Nourse (513) 255-4429	88, 90, 91			Y		Y
Lockheed Dan Fisher (404) 494-3107	Lockheed		Y	Y	Y	Y
McDonnell/Douglas Helicopter Rick Esquibel (602) 891-8423	88		Y			
NAWCADWAR Donald Booz (215) 441-2154	CNA 88			Y		

Table 4.0-3 Specific Results of Survey and Follow-up

Organization/ Firm POC	ALARM Version	Test Data	Other Models Compared	Problems Found	In-house Doc	In-house CM
Texas Instruments Camilla Haley (214) 575-5412	88	Y		Y		
AFOTEC/ST Maj. Keith Carter (505) 846-5328	90, 91	Y	Y	Y	Y	Y
RAND Corp Dr. Greg Born (310) 393-0411	88	Y	ESAMS	Y		
Loral Electronic Systems Jim Foreman (914) 964-3793	81, 86, 88, 90, 91	Y		Y		
CD/NSWC Dr. A.J. Stoyanov (301) 227-5772	91		EREPS			
SAIC/WPAFB Larry Janning (513) 429-6518	86, 88, 90, 91		TRAMS	Y		Y
STRATJIC/DDP Capt. Clarence Reif (402) 294-4675	91	y	TRAMS	Y		
McDonnell Douglas Paul Barr (310) 593-5594	88		Y			
Survice Engineering Robert Strausser (410) 273-7722	88		ESAMS 1.6			

4.1 V&V STATUS

There have been very few formal ALARM-specific V&V efforts over the years, and even fewer have documentation available. The following paragraphs identify the most prominent of those efforts. Note that many of the projects described below are not classical V&V efforts. Rather, they are studies which involved comparison of ALARM results with field test data and/or output from other models. Because of these comparisons, the studies are categorized as V&V efforts.

1. Since 1992 the SMART Project has sponsored the verification and validation of ALARM, examining versions 91, 92, 3.0, and 3.1. Hundreds of model runs have been made in support of sensitivity analysis, verification, and validation testing. Results to date have been significant, with more than two dozen deficiencies identified and corrected. Additionally, field test data collected with several different

radars at different locations around the country have been analyzed. The data have been invaluable in understanding modeling limitations and the difficulties in collecting useful field test data. This document presents some of the results of that SMART Project effort. See ALARM ASPs II and III for more details.

2. In 1988-89, Dr. Paul Muessig at the Center for Naval Analyses (CNA) performed validation work using Naval Weapons Center (NWC), China Lake, CA, range data and data from flight tests over water at Eglin AFB. Using two separate sets of test data, one at NWC's Echo Range, the other at Eglin AFB, FL, CNA assessed ALARM to be an accurate predictor of the detection of the EA-6B at low altitudes.

   From the 1988 work, CNA studied diffractive effects, and determined that weather conditions produced a surprising amount of anomalous propagation, even for high altitude targets. They identified several areas for model improvement. Details are reported in the CNA report CRM 88-235, *Radar Model Validation in Support of EA-6B Tactical Development; Echo Range Results (U)* [18].

   The second test collected detection data from a pulsed radar tracking a moderately-sized RCS ($< 10m^2$) target, in a maritime environment at Eglin AFB, FL. CNA determined that ALARM-predicted detection ranges of the EA-6B were within 15% of the actual detection ranges, and that these predictions were in agreement with measured data over 80% of the time. Detailed results are reported in the CNA report CRM 89-99, *Eglin Range Results of ALARM Radar Model Tests (U)* [19].

3. Over a period of years, MIT's Lincoln Laboratory (LL) has compared ALARM model results with those from their proprietary in-house radar model, TRAJ. LL has performed its tests using ALARM 88, ALARM 91 and ALARM 3.0. This effort has had special importance because of the introduction of LL's copyrighted Spherical Earth/Knife Edge (SEKE) diffraction and multipath propagation algorithms into ALARM 91. Results have been briefed in the ALARM Users Group meetings in 1992-94, and have shown very good correlation between TRAJ outputs and the T-38 target signal data recorded with a classified radar. Due to

security concerns, this work has not been formally (in writing) reported to the user community. LL has reported some correlation between TRAJ results and those of ALARM. There have been discrepancies between the models due to differences in the multipath logic used. LL is currently reviewing the SEKE code in ALARM 3.0 and comparing it to TRAJ/SEKE. The purpose of this review is to resolve the differences. A report on the problems found and recommended code changes is anticipated in the future.

4. One documented study using ALARM is reported in the *Modeling of Radar Clutter and Propagation for Surface-to-Air Missile Simulations* [12]. According to the study,

> In late September of 1992, a joint project between the Defence Research Establishment Valcartier (DREV) and the US Army Materiel Systems Analysis Activity (AMSAA) was begun under a US-Canada Memorandum of Understanding....It was decided that the research would concentrate on the modeling of two factors affecting the performance of radar seeking missiles: ground clutter returns and radar propagation. The study focused on two simulations, ALARM91 and IMARS (a suite of radar seeking surface-to-air missile simulations). ALARM was used as the basic evaluation tool, and several different clutter models were developed and added to the model, along with additional terrain modeling capabilities. The study concluded that effects of terrain on propagation tend to affect target detectability more than clutter, and hence that engagement models which do not model terrain may yield unrepresentative results. It also found that the best radar propagation models currently available predict specific values for the propagation best at low frequencies and altitudes, and give correct trends rather than specific values at higher frequencies and altitudes. It also found that no radar clutter model currently available can predict site specific clutter values, and that some form of random clutter modeling using experimentally derived clutter statistics best reproduces the character of clutter.

5. In 1992 AFOTEC/ST commissioned Dr. Dave Fisher of PRC, Inc., to evaluate the version of ALARM91 (ALARM91m) modified for inclusion in the modeling system ACES/Phoenix (A/P). Within A/P, ALARM can be run in either “native mode” or in an integrated mode, employing the A/P triangular terrain, environmental zones, flight path generator, composite signal generator, generic radar clutter estimator (GRACE), and clutter map generator. Dr. Fisher focused on those algorithms which impact low observable studies, namely, clutter generation, clutter rejection, propagation factors, and noise. The

evaluation was not considered a validation, but many conclusions were aimed at the effects that the algorithms may have on validation efforts. His work is published as the *ALARM 91 Model Evaluation Report* [13].

The following section summarizes survey responses and telephone correspondences with POCs who answered the questionnaire cited in the introduction to this section. The survey reflects work completed in 1992. Additional work has been done since then and contact information may be out of date; however, the information presented here should give the user confidence in the number of users and the recent VV&A work they have performed using the model. Entries below have been placed in inverse chronological order.

1. AFOTEC/ST, Major Keith Carter, Major Jeff Campbell, (505) 846-5328: Validation activity has included several studies using ALARM 88, ALARM 91, and ALARM 3.0. Short reports (7-15 pages) were written on these studies; all are classified SECRET/NOFORN/WNINTEL. The reports include the Red Book Study, MISC Comparison Study, and Independent Comparison Effort. These reports are not available to other users.

2. 544th SIW, Captain Clarence Reif, DSN 271-4675: Capt. Reif conducted several studies using different versions of ALARM. His work included: (1) calibrating the initial antenna elevation angle, useful for improving the accuracy of model results; (2) comparison testing of ALARM88 and ALARM91, which showed no significant differences in model results; (3) independent testing of ALARM91, which revealed a factor of two error in noise predictions; and (4) comparison of ALARM90 and ALARM91 results with output from the TRAMS model and field test data, resulting in identification of MTI, antenna, clutter, and SEKE errors.

3. SAIC/WPAFB, Larry Janning, (513) 429-6500: Mr. Janning conducted studies using ALARM 86, 88, 90, 91, and other versions. The model results were compared with those from the TRAMS model and with field test data, revealing some algorithm errors.

4. CD/NSWC, Dr. A.J. Stoyanov, (301) 227-5772: Dr. Stoyanov compared ALARM91 results with the EREPS (Engineer's Refractive Effects Prediction System) model at NAVOCENSYSCEN; the results were nearly identical. Dr. Stoyanov reported having a high regard for

ALARM because of this comparison. EREPS has been used for at least six years. NATO has sponsored EREPS validation efforts, and results have proven EREPS to be very credible.

5. Loral Electronic Systems, James J. Foreman, (914) 964-3793: Mr. Foreman directed studies that used ALARM versions 81, 86, 88, 90, and 91. One such study validated the detection range for ALARM 81, against a cruise missile. The actual detection range vs. model prediction was within 0.4%. In other studies, ALARM results were compared with output from other models and with field test data; some errors were found.

6. ASC/XRE, Klaus-Peter Bletzinger, (513) 255-2821: Mr. Bletzinger performed studies using ALARM versions 86, 88, 90 and a Navy version. ALARM results were compared with field test data (SECRET and TS) and output from other models. Numerous problems or errors were found.

7. IDA, Merle Roberson, (703) 845-2273: V&V activity referred to in the questionnaire response was actually an ALARM modification used in estimating multipath and clutter effects for ground radar/ground target studies. Mr. Roberson decided that ALARM would not be easily modified to model such studies, and therefore he does not use ALARM.

8. McDonnell Douglas, Paul Barr, (310) 593-5594: Mr. Barr used the ALARM 88 version to accredit a classified project, in which ALARM results were compared with other models.

9. McDonnell Douglas Helicopter Company, Rick Esquibel, (602) 891-8423: ALARM 88 results were compared with output from other models in a SECRET report.

10. NAWCADWAR, Donald Booz, (215) 441-2154: The ALARM 88 version was used by CNA to developed an in-house “CNA Round Rough Earth ALARM.” Mr. Booz found some ALARM code errors.

11. SURVIAC, Denny Detamore, (513) 429-9509: ALARM 87 (sic) and ALARM 88 results were compared with output from other models. Inputs and code errors or problems were found. Mr. Detamore developed descriptive documentation for in-house use.

12. SURVICE Engineering, Robert Strausser, (410) 273-7722: The ALARM 88 version was used, with results compared with ESAMS 1.6 model results.

13. Texas Instruments, Camilla Haley, (214) 575-5412: The ALARM 88 version was used with results compared with test data. Code errors or problems were found.

14. RAND Corporation, Dr. Greg Born, (310) 393-0411 x6757: The ALARM 88 version was used for a comparison of clutter modeling results with ESAMS 2.7. Both clutter power calculations and clutter attenuation in one threat radar of interest were compared. Two significant modeling differences existed in the clutter power calculations: ESAMS used clutter masking based on range from the radar and clutter reflectivity as a function of grazing angle which ALARM 88 did not. When these differences were removed, the computed clutter powers agreed closely in the two models. Clutter attenuation in the radar receivers was quite different in the two models and was found to be a consequence of different antenna beamshapes and Doppler filter characteristics.

15. Grumman Northrop ESD-RMS, Jeff Zeller, (708) 259-9600 x24812: Mr. Zeller used ALARM 86 to write an internal position paper describing the ALARM implementation of several algorithms. In the opinion of Mr. Zeller, such verification information probably will not help other ALARM verification efforts due to extensive ALARM upgrades over the years. (ALARM 86 only used round smooth earth approximations.)

16. Lockheed, Daniel Fisher, (404) 494-3107: Mr. Fisher described his V&V activities as a comparison of ALARM and ESAMS detection histories, obtaining a 95-98% correlation between model results. A difference in masking predictions for the two models was found, which Mr. Fisher attributed to differences in the DMA data interpolation schemes used by the two models.

4.2 USAGE HISTORY

The following paragraphs summarize additional applications using ALARM. There is not much documentation available defining the studies in which users have employed

ALARM. This is due to two main reasons. First, many of the studies are conducted for classified programs. Second, other studies are proprietary in nature, being used by the designers of aircraft, radar, and ECM systems. Documentation of either type of study is generally not available without special permission and/or security clearances. As the ALARM ASPs mature over time, more information about applications of ALARM could become available.

The following paragraphs briefly describe six projects using ALARM. Information on other projects may be available from individuals listed in Appendix B.

1. A classified project begun in 1995 is being conducted by Jeffrey L. Talley, a student at the Naval Post Graduate School, and Andy Hernandes of the Defense Evaluation Service Agency. ALARM, ESAMS, and RADGUNS are being used to generate inputs for JANUS, a campaign-level model.

2. During the fall of 1993 to spring 1994, SAIC/Austin modified ALARM 3.0 to create two different versions of the model, JEWC/ALARM and a time-based ALARM. JEWC/ALARM, so called because it was built under contract for the Joint Electronic Warfare Center (now named the Joint Command and Control Warfare Center), implemented the following changes to the model: (1) input was restructured to make use of a Graphical User Interface; (2) clutter processing was rewritten to allow sea clutter to vary as a function of wind speed and land clutter to be defined in terms of azimuth and range; (3) a Blue Max flight path generator was added; (4) multiple targets were added; (5) a DMA compact disk file processor was incorporated; and (6) the model was ported to the C language from FORTRAN. Time-based ALARM includes all of the JEWC/ALARM enhancements but also contains a Plan Position Indicator (PPI) display for model output. Additionally, JEWC/ALARM is not time based. The principal investigator for both of these projects was Steve Mynes, SAIC/Austin, (512) 219-5520.

3. In 1984, SAIC used ALARM extensively in support of the AFAL Low Observable Electronic Warfare Studies (LOEWS). All reports of this effort were returned to the project office.

4. In 1980, SAIC conducted two separate analysis programs for the AFAL using ALARM: one to evaluate high-powered stand-off jamming

systems and the other to assess advanced night in-weather tactical fighter concepts. No known reports of this work remain available.

5. In 1978, SAIC/Albuquerque, NM, used ALARM to predict the outcome of air- and sea-launched cruise missile flight tests against the White Sands Missile Range (WSMR) and Nevada Test Range (NTR) radar system assets. This work was performed for the Joint Cruise Missile Program Office (JCMPO). Some successful end-to-end validation was performed with ALARM modeling search and acquisition radars. All results of this project were returned to the program office.

6. ALARM was designed to provide analysis of the detection performance of ground-based radar systems against aircraft targets. The model was originally developed in 1974 by CALSPAN, Buffalo, NY, for use on the Penetration Aids Evaluation (PENVAL) program for the Air Force Avionics Laboratory (AFAL), Wright-Patterson AFB, OH. No documentation is believed to exist from this period.

4.3 IMPLICATIONS FOR MODEL USE

ALARM is a mature model with a large number of users, many of whom have looked at details of the model's implementation. ALARM has been used in many DoD studies as the primary tool for analyzing ground-based radar performance. It has often been employed for the design and development of new radars, noise jammers, and aircraft. It has been incorporated in the ACES/Phoenix modeling framework designed and built by AFOTEC and STRATCOM to support operational testing of the B-2A "stealth" bomber. Because of such extensive use, it is generally a good choice for analyzing the effectiveness of ground-based radars.

ALARM V&V efforts have been broad in scope and of considerable depth in recent years, resulting in better code and documentation. The analyst attempting to accredit ALARM for a new study can have high confidence in the accuracy of both the design and the code based on both its prior history of use and its substantial V&V history.